## Aviation in the 21st Century: Beyond Open Skies Ministerial Remarks of NASA Administrator Daniel S. Goldin Chicago, Illinois December 6, 1999

## World Aviation in the 21st Century

Good morning everyone. Thank you for being here.

I would like to salute Secretary Slater of the Department of Transportation and Administrator Jane Garvey of the Federal Aviation Administration. You demonstrate an incredible dedication to ensuring the safety of the skies every day, and we all appreciate your efforts.

I also want to acknowledge our many friends from around the world who are here today. You all know the importance of aviation to the world's economy, and your attendance at this important meeting shows your commitment to strengthening the world's aviation system.

I am pleased to be here for the rollout of the NSTC (National Science and Technology Council) R&D Plan for Aviation Safety, Security, Efficiency and Environmental Compatibility, and I want to thank everyone who worked so hard to make this report a reality. This plan is a blueprint for NASA, FAA and DoD to achieve national civil aviation priorities and it is a foundation for strong public private partnerships.

It is an essential first step in ensuring that our aviation system will meet the unbelievable challenges we face in the 21<sup>st</sup> century. And I am proud that NASA and our partners at the FAA and DOT are working on these important issues.

On Friday evening, I will fly to the Kennedy Space Center. The third servicing mission for the Hubble Space Telescope will be launched after midnight.

Hubble was launched 10 years ago, with the plan calling for it to have a 20-year mission life, to take observations from the visible part of the electromagnetic frequency spectrum

And we planned it, built it, and deployed it so we could reach it — in a circular orbit just 360 miles above Earth. This is the only one of our four Great Observatories we can reach with the shuttle. The observatory and our servicing plan have proven to be very beneficial.

We're able to get countless amazing images from Hubble, and it has been an incredible breakthrough for scientists. Hubble has brought the universe into our living rooms. And with each servicing, the quality of the observations has improved.

I'm telling you this, because I want us to think the same way about the aviation system of the new millennium.

We need to develop a system that will provide tremendous benefits to all of humanity, while enhancing economic opportunity and preserving the environment. To do this we need a visionary plan that the entire aviation community can follow and we need it to be flexible enough to be able to improve it as market and technology innovations occur.

Before we get too far ahead of ourselves, let's take a look at where we are and where we may end up if we don't rise to the challenges before us.

Aviation is the dominant mode for long distance transportation. In America fifty percent of all travel over 1000 miles is done by air and 75% over 2000 miles. Aviation is fundamental to how we live and work and enables the fast-paced, high-tech economy that has led to the record economic expansion this country and most of the rest of he world is enjoying.

For the foreseeable future, the number of airline passengers is expected to grow at about 5% a year. America's hub and spoke system carried 680 million passengers this year. A number that will exceed 1 billion early next decade and reach 1.5 billion by 2020.

You can pick-up a paper almost anywhere in the U.S. and read about the problems aviation is facing – from the inability to build more runways, to

excessive delays, to community protests over noise. And the situation isn't much better in the rest of the world either.

Some of the articles conclude that aviation <u>will not</u> be able to sustain growth because of these issues and limitations. In fact, there are probably people in this room that have come to the same conclusion!

We are well on our way to hublock.

A problem in one hub quickly radiates out across much of the system. And if we do not safely and quietly increase capacity in a dramatic way, the integrity of the scheduling system will completely fall apart.

Just imagine how that would change the flying experience.

Curb-side check-in? Forget it, because no one will know which flight they will take.

Frequent flyer programs? A thing of the past, because the airlines will have all of the business they can handle without incentives.

First-class lounges? Too expensive to maintain, because too many people will need to spend too much time in them.

And families will never know when or where to pick up loved ones, because the airlines won't know flight numbers until passengers board or gate numbers until planes land.

Because of the uncertainty, you can guarantee there will be even more delays. Picture long lines of planes, engines running and creating noise and pollution, waiting either for a gate to open up or for a take-off slot.

One thing that won't change are those long, winding lines at the check-in desks. They'll get longer. Much much longer.

This is a pretty gory picture. It doesn't have to be this way though.

Global economic growth has played a major role in stimulating air travel, so we must not allow air travel to hinder future economic growth.

So what can we do?

Simple. We have to find the best solutions possible. In conjunction with the FAA, we have to set up a methodology for future planning. It has to be a cooperative effort between the public and private sectors.

For instance, we will be organizing a series of workshops with the FAA to address various aviation issues, and we hope you will get involved too.

For us to make the 21<sup>st</sup> century the century of aviation, we will need radical new solutions to the challenges we face.

Now I can't tell you with absolute certainty what the aviation system of the future will look like. But I can take you on a flight of fancy that represents one possible version of the future, based on some of the technologies we're working on today.

Looking up into the sky of tomorrow, you'll probably see the commercial wide-bodies flying over, just like today. Maybe we'll even see more and more supersonic aircraft—<u>if</u> we're able to suppress the sonic booms. Maybe some unpiloted aircraft or runway independent aircraft that help us to fully utilize our airspace.

Or a semi-buoyant airplane that carries large loads of cargo in response to the boom in Internet shopping and the need of rapid delivery of goods and services. Or a solar powered aircraft acting as a relay station for communications or disaster relief efforts as it hovers above an area that was ravaged by a hurricane.

Don't forget the numerous smaller personal aircraft that people will use as rentals or even taxis. And perhaps in the midst of all this, reusable launch vehicles will regularly move in and out of our atmosphere.

The possibilities are only limited by your imagination.

The fully — and safely — utilized airspace I envision has the potential to dramatically increase the quality of people's lives throughout the world, it also presents us with daunting challenges to our environment and the safety and efficiency of our aviation system.

But when we work together to develop revolutionary new technologies, we will see some incredible results.

For instance, imagine that aviation accidents become a thing of the past. Planes are not just a factor of 10 safer but 1000 times safer – a one in a billion occurrence of accidents, compared to 1 in a million today. People will have complete confidence in air travel, because they can safely fly to visit family and friends or conduct business whenever they want.

I'm talking about smart airplanes that are self-diagnosing and self-repairing. Planes that sense hardware failures and pilot errors. Planes that notice and compensate for pilot stress and fatigue.

And planes that have total full-time and real-time situational awareness.

We'd have imbedded sensors for full-time, real-time updates on all aspects of vehicle health.

And what if something goes wrong? Something out of the ordinary?

There's a technique called Model-based reasoning, where an anomaly is not taken at face value. Instead, as many different indicators as possible are read and analyzed to assure an accurate diagnosis of the problem.

For instance, if a "faulty valve" light comes on, but other gauges show that flow is still taking place downstream from the valve, you can assume that the warning is erroneous, so you won't take inappropriate action.

Is there another level of safety?

Sure there is. Neural networks.

Neural networks assimilate vast amounts of data and extract information – trends, patterns, solutions--the kind of thing we do when we learn and think.

Today we can build systems with hundreds to thousands of neural connections. In the future they will have millions of connections in a package the size of a sugar cube.

NASA applied neural networks to the flight controls of an F-15 aircraft. The traditional flight control software system required one million lines of code. We reduced it to about ten thousand.

We simulated the loss of an aileron roll control surface, and the system adapted and returned aircraft control authority. Within milliseconds, the system perturbed the functioning flight controls and the differential thrust control on its engines – to achieve the correct aircraft response to the pilot's commands.

Because of their inherent intelligence, neural networks <u>could</u> and let me reemphasize <u>could</u> lead to a plane that helps the crew keep it from crashing.

In other words, if a pilot over-reacted to a warning, the neural network might be able to recognize the illogical reaction and prevent the pilot from doing it.

And speaking of the pilot and crew, what if we could monitor the crew's hormone levels, measuring their alertness and focus?

What if we had machines that could provide us early indications of stress or panic?

And what if we could get that feedback in real-time?

We're working on technologies to do that for our aircraft—the integrated vehicle health monitoring system. Why can't we have it for the crew too?

Now imagine how much safer plane flight would be if we could integrate responsive vehicle and crew health systems with a revolutionary enhancement of the pilot's view through the cockpit window — one that could make a foggy late night flight look like a flight in full visibility daylight...at least to the pilot.

We're already developing artificial vision — an integrated system of advanced sensors, digital terrain databases, accurate geo-positioning, and digital processing to provide a perfectly clear 3-D picture of terrain, obstacles, runway, and traffic.

This goes beyond simple visual imaging through clouds and weather.

It artificially creates the entire environment, enhancing the elements you need to see and suppressing the ones you don't. It will ensure a reliable and easy system for threat avoidance, regardless of whether the threat is a mountainside or a recently constructed transmission tower. And it will provide clear warning advice and guidance to the pilot.

Next year's Shuttle Radar Topography Mission will provide incredibly detailed mapping of the Earth between 60 degrees North and 60 degrees South, to an accuracy of 20 meters. That's more than enough detail to help pilots avoid terrain hazards.

A futuristic, integrated system would also give pilots a 3-D depiction of complex weather patterns, including locations of hail shafts and wind-shear, lightning and storm cells.

The real-time "Now-Cast" could also show airborne hazards like volcanic ash, high upper-level winds, icing or lightning. It'll give us a pathway — the highway in the sky — for safely navigating through nearly any weather condition, including clear air turbulence, a major safety concern.

Clear Air Turbulence results in hundreds of passenger injuries each year. Timely warning could prevent most of these.

We can already use LIDAR — in effect a light radar — to detect clear air turbulent conditions about 10 seconds ahead of the aircraft. We're working to stretch that timeframe into minutes — more than enough time for passengers to buckle up and for flight attendants to strap down service carts.

The flying public will respond positively to safer planes, but only if they can also rely on the planes to get them to their destinations without hublock-generated delays.

Imagine a future where airport delays only occur very rarely — in very extreme cases like natural disasters. And when delays do occur, their impact is only local, not system-wide.

In such a future, people save time and money and air travel continues to foster economic growth rather than limit it.

I'm talking about optimizing terminal area productivity with high reliability and safety — no more holding patterns in the air or long lines of planes waiting for takeoff slots.

I'm talking about a safe and flexible system that gets people closer to where they want to go and frees them from dependence on the hubs. A system where Internet planning and scheduling enable a seamless transfer from large transports to air taxis and other modes.

Even with the current airport and fleet infrastructure there is a lot of untapped capacity. With precise knowledge of aircraft position and flight path and the ability to communicate that knowledge in real time we can get about 50% more capacity -- and not just in clear weather, but also in low visibility conditions. We're developing those tools with the FAA now.

However to implement those tools we need to get going on a modern communication and information infrastructure for aviation.

One tool is the Final Approach Spacing Tool (FAST), which has been tested at the Dallas-Fort Worth airport. The result? A 13-15% improvement in numbers of safe takeoffs and landings—the equivalent of adding a new runway.

We are also working on a wake vortex sensing and prediction system that allows controllers to more accurately space aircraft on approach. One recent study suggests that reducing the average aircraft separation by one mile could increase total capacity by 30%.

New aircraft classes could off-load the main runways of our nation's most congested airports and decrease costs and increase accessibility in the short-haul system. This will include Runway Independent Aircraft capable of take-off and landing on whatever ground is available—independent of size and direction.

We will also need to develop more efficient route selection processes in order to accommodate increases in air traffic. What about direct routing? It would eliminate the constant re-vectoring that goes on now, saving energy and increasing the safety and capacity of our airspace.

And smart airports with virtual control towers that are integrated into the total aviation system and linked to smart aircraft will open up every one of the over 5000 existing airports in America to many types of aircraft, decreasing the stress on our hubs and dramatically increasing total system capacity.

You may think, "the public may not allow major increases in capacity because of noise and pollution concerns."

I say imagine a world where people <u>want</u> airports in their neighborhoods. People will appreciate the convenience nearby airports provide, and with revolutionary technologies, the air will remain clean and quiet.

I'm talking about the end of smog producing exhaust (NOx).

How can we do this?

We recently demonstrated a full-scale annular combustor for jet engines that produced 50% less NOx than current standards and we are already working on one that can produce 70% less NOx. This is going to ensure that in the long-term aviation will not cause local air quality problems.

I'm talking about airports where noise is within normal acceptable limits. Where there is no longer a footprint of this noise outside the airport boundary when a plane takes off. The levels of perceptible noise around airports should be so low that people aren't concerned about planes going by.

One method has been to increase the bypass ratio. And that has created a lot of the noise reductions we're seeing today.

In the future, there are some other technologies that may prove useful, such as skewed fan blades, tabs, chevrons, and exhaust nozzles to alter exhaust flow. We're working on engine fan blades precisely designed w/ 3D accurate flow analysis to reduce noise.

What about advanced wing and fuselage designs to dramatically reduce drag? Lower drag could mean smaller and quieter engines.

Smart engine technology would make our engines better too. They would have active control of engine performance, with temperature, air and fuel flows optimized during various phases of the flight. And when we link smart engines with smart planes, the total system gets better.

And there is some work to be done on the airplanes themselves. Once the engines become quieter, much of the remaining noise will come from airflow over wings, flaps, and landing gear.

But what if we had morphing wings that eliminate the need for flaps? Wings that adapt and adjust to aircraft takeoff and landing needs like birds' wings do.

Why can't we develop materials and imbedded actuators that would mimic the way birds fly?

What if we had integrated body/wing assemblies that dramatically reduce an aircraft's drag?

Or what if landing gear could be designed to dramatically reduce the noise generated by the fairing during approach?

Let your imaginations run a little wild here. That's the only way we will fully solve the noise problem.

Now I have talked about a lot of different technologies today—some we're already working on with the FAA, some are in use on our spacecraft, and others we are exploring but haven't developed yet. But these are the technologies we will need to meet the challenges aviation faces in the 21<sup>st</sup> century.

As we meet these challenges, we will re-ignite the explosion in aviation technology.

And we will re-ignite our kids' excitement for science and technology.

It's not just about the future of aviation. It's about the future of our world.

That's what NASA wants to do, and it is one path to an exciting and dynamic future for aviation.

In closing, let me come back to the Hubble Space Telescope. As I said, the world has been transfixed by the amazing images this Great Observatory has sent back to Earth.

One of the most interesting things about Hubble is that it is a lot like the world's aviation system: every component needs to do its job for the entire system to be successful.

Friday's mission will replace the directional gyros on-board the telescope so it can continue fulfilling its mission. Without those gyros, Hubble has to close up shop and stop sending images back to Earth.

Similarly, today's aviation system cannot meet the incredible demands of the new millennium. And a piecemeal approach won't move us forward to tomorrow's system.

Instead, we need to set a plan for where we want to be. And the plan we are releasing today is a strong first step. Now, we all need to come to a consensus, get to work, and move to the future together.

That means we not only need to develop an integrated aircraft/airport system, we also need to work on all our needs at once. We can't just increase capacity or safety or reduce noise alone. We need to strive toward these goals simultaneously.

That way, our aviation system will be like the Hubble Space Telescope. Just like Hubble has opened up the universe to millions of people, the aviation system of the future will open the corners of the world to more and more people.

And as we develop that system, we will ensure that the new millennium is the aviation millennium.

Thank you very much.